Scaling Excellence: A Case Study in Implementing an Asset Integrity Program

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Abstract

Asset Integrity Management (AIM) systems must establish policies, standards, procedures, and activities that ensure the equipment and process piping are properly designed, installed per specifications, and fit for their intended use over their life cycles using industry standards and manufacturers' recommendations. This technical paper will discuss implementing an AIM program for a global chemical and pharmaceutical Company. The discussion will include developing the broad asset groups and relevant challenges, obtaining stakeholder buy-in for the implementation methodologies, and managing a measured rollout with global training and a simple performance indicator to track implementation progress. Implementing an AIM program requires management commitment and vision to ensure its success, qualified individuals to identify all included equipment, flexibility to adopt relevant regulations, collaboration to create compliant and reasonable policies and procedures, and coordination to seek buy-in, conduct training, and improve the program continuously.

1 Introduction

Implementing an Asset Integrity Management (AIM) program requires organizations to create their equipment and piping lists for Inspection, Testing, and Preventive Maintenance (ITPM) in the PSM-covered process (often called included equipment). The list can be grouped into categories that guide ITPM requirements and ensure compliance with recognized industry codes, standards, and recommended practices as mandated by OSHA's Process Safety Management (PSM) standard[1], 29 CFR 1910.119. Operating companies can also choose to create critical equipment lists to prioritize included equipment that helps prevent or mitigate catastrophic incidents, such as safety instrumented systems (SIS) or fire protection equipment.

The Company in this case study had an equipment list that was grouped into categories, including fabricated equipment, pre-engineered equipment, pressure relief devices, electrical equipment, critical interlocks, and fire protection systems**,** each governed by relevant industry standards and/or manufacturers' recommendations. As the AIM program evolved, additional categories, such as a gasket management program and infrastructure, were incorporated to address previously overlooked equipment categories and their associated risks.

Beyond the initial work of creating equipment lists, grouping the equipment, and understanding the relevant standard, successful AIM implementation also requires stakeholder buy-in, ongoing training for the AIM representatives, flexibility in execution, and the recognition of additional safety programs such as electrical safety. The structured rollout emphasized following the Company's program requirements to ensure compliance with OSHA's PSM mechanical integrity element to prevent loss of containment and the resulting incidents. This technical paper outlines the approach taken, challenges encountered, and key lessons learned in successfully launching a global AIM program for a chemical and pharmaceutical company.

2 Defining Equipment Categories for AIM Program Implementation

When implementing an AIM program, an organization must first determine the categories of equipment that will be maintained. These equipment groups are typically managed according to how they are procured and the accepted standards that apply to them. The Company created the following categories:

1. Fabricated equipment – Equipment and piping whose specifications were determined by the Company using industry standards such as the American Petroleum Institute (API) and the American Society of Mechanical Engineers (ASME) and that are maintained by standards from these organizations.
2. Pre-engineered equipment – Equipment bought off the shelf or "as is" based on the stated specifications with maintenance requirements primarily provided by the manufacturer.
    a. Pressure relief devices – Equipment is bought off the shelf based on the specifications but is maintained per ASME, API, or National Board Inspection Code (NBIC) standards.
3. Critical Interlocks and Safety Instrumented Systems (SIS) – Equipment specified in the risk assessments as safeguards or Independent Protection Layers (IPLs) to mitigate or prevent higher-risk scenarios. These instruments are maintained by the International Electrotechnical Commission (IEC) 61511, *Functional safety – Safety instrumented systems for the process industry sector standard.*[2]
4. Electrical equipment – The main and backup power to the facility with maintenance is based primarily on the National Fire Protection Association (NFPA) 70B standard.[3]
    a. Bonding and Grounding – Individual lines, spools, and networks in the facility to prevent static electric sparks when transferring combustible and flammable material based upon NFPA 30, Flammable and Combustible Liquids.[4]

5. Fire Protection Equipment – Equipment that includes sprinklers, deluges, extinguishers, etc. This equipment is maintained using the applicable NFPA standards, such as NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.[5] Others include NFPA 10 for portable fire extinguishers[6] and NFPA 12 for carbon dioxide fire-extinguishing systems.[7]

These broad categories provide a framework for training the organization on their definitions, procurement, and maintenance requirements, and the standards that apply in most cases. As the standards are chosen, an organization must ensure they are Recognized and Generally Accepted Good Engineering Practices (RAGAGEP), which is required under the OSHA PSM mechanical integrity element.

As the equipment categories are finalized, it is good practice to create a definition and requirement for critical equipment. The PSM standard does not require this, but Appendix C, section 9. Mechanical Integrity, which is non-mandatory, states, "For the categorization of instrumentation and the listed equipment, the employer would prioritize which pieces of equipment require closer scrutiny than others." A critical equipment list allows a company to list the IPLs and safeguards that mitigate or prevent higher-risk scenarios and the equipment whose failure could initiate them.

When defining the critical equipment list, organizations should be very clear that it is only related to potentially catastrophic events. Other critical equipment will exist, such as for quality, that are very important, but do not belong on this list. Suppose a company runs out of time, money, or manpower to complete everything on the shutdown or maintenance lists. In that case, the critical equipment list must be prioritized to protect the personnel, assets, neighbors, and environment. Additional inspection, testing, and preventative maintenance beyond RAGAGEP may also be needed for critical equipment to address identified damage mechanisms, remaining corrosion life, the equipment age, the equipment environment, or known deficiencies.

After launching the program with these categories, the Company discovered that two equipment categories were missing: a gasket management program and infrastructure. The gasket management program was created and placed under pre-engineered equipment. Many existing risk assessments had recognized that a failed gasket from equipment or piping that contained flammable or toxic material could be an initiating event to a fire or toxic exposure; however, there was no safeguard or IPL to prevent this failure. The gasket management program was created to ensure the proper gaskets were purchased based on the material being contained and stored correctly. Regular gasket inspections were also required, which were often conducted under existing Leak Detection and Repair (LDAR) programs.

While creating the gasket management program, the Company's Subject Matter Experts (SMEs) determined that a torquing standard was also required. A torquing standard was then created and rolled out to ensure the proper torquing pattern and force were applied to the gasket flanges. The Company had seen previous issues with leaks that had occurred due to tightening the bolts in a circle, which forced the gasket to one side. Bolts that were only tightened rather than torqued were sometimes too loose or too tight. The Company required flanges in services where the bolts were known to come loose over time, such as in services with high vibration, to have the bolts retorqued on a set frequency.

The second equipment category addition was Infrastructure. Some of the facilities were very old and the infrastructure was failing in places, but the program did not address this issue. Infrastructure was a new category and required the facilities to inspect the infrastructure and correct deficiencies on a prioritized risk basis, considering the consequences of failure. One high-risk example was a failing rack over a roadway that supported highly hazardous chemical piping. This rack was prioritized to the top since its failure could cause a significant loss of containment and the potential for employee exposure, fire, and/or explosion.

Based on the experience of both authors, the following equipment may also be missed when creating or improving an AIM program:

- Nonmetallic linings of pressure vessels
- Dead legs
- Underground piping
- Critical check valves
- Critical utility systems
- Transportable storage containers (including railcars)
- Vendor-supplied equipment

As organizations create or improve an AIM program, they should be prepared to add to and modify the equipment categories and requirements as gaps are identified.

3 Complying with the RAGAGEP Requirement

When creating or improving an AIM program, the scope and applicability of RAGAGEP should be clearly defined. Some Company facility experts believed that they could solely rely on their experience in setting equipment Inspection, Testing, and Preventive Maintenance (ITPM). The OSHA PSM standard and EPA Risk Management Plan (RMP) 40 CFR Part 68 standard[8] define RAGAGEP, and personal experience is not included in initially setting ITPM. To be compliant, a company must use RAGAGEP as defined by the standards.

OSHA Refinery National Emphasis Program (CPL 03-00-004)[9] references the CCPS Guidelines for Mechanical Integrity Systems book for its definition of RAGAGEP:

> "Engineering, operation, or maintenance activities based on established codes, standards, published technical reports or recommended practices (RP) or a similar document. RAGAGEPs detail generally approved ways to perform specific engineering, inspection, or mechanical integrity activities, such as fabricating a vessel, inspecting a storage tank, or servicing a relief valve."

Additionally, API 592 "Elements for the Establishment of a Fixed Equipment Mechanical Integrity Program[10]," which is being considered, provides a sample framework for an AIM program, which incorporates various levels of implementation based on the relevant regulations and standards as they flow to the other documents, including:

- Regulations and Standards
- Policies, Processes, and Systems
- Programs
- Practices and Guidelines
- Detailed Procedures

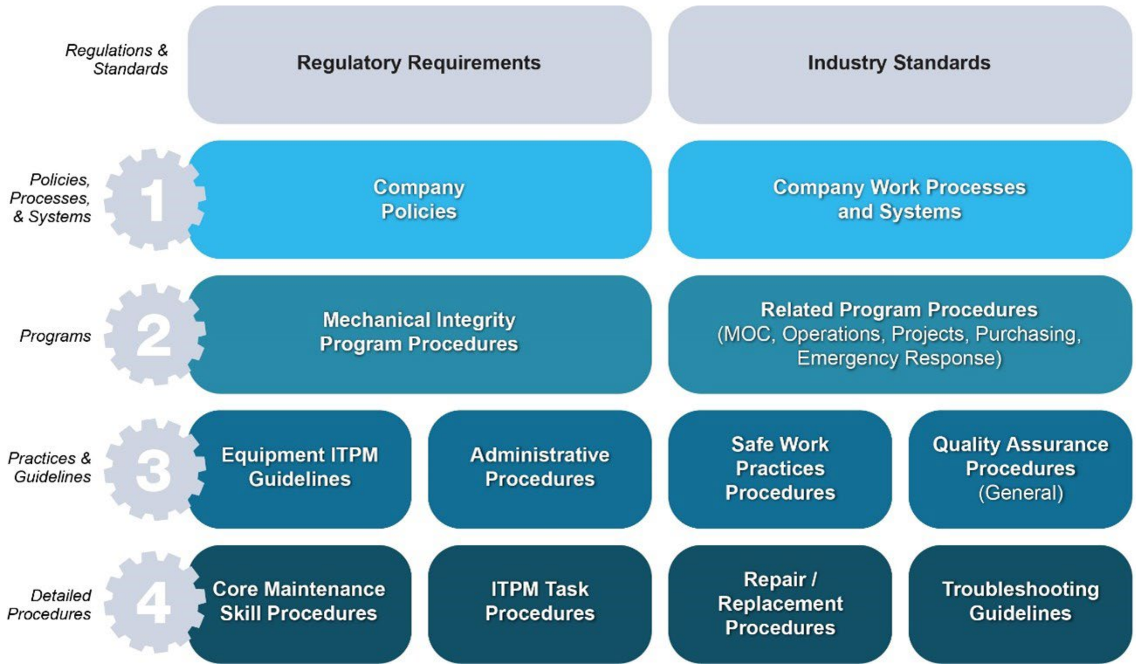

Figure 3-1: Sample Asset Integrity Management Framework from ioMosaic

OSHA also states in the PSM standard, under Mechanical Integrity, that "the frequency of inspections and tests of process equipment shall be consistent with applicable manufacturers' recommendations and good engineering practices, and more frequently if determined to be necessary by prior operating experience." In this case, changing to more frequent inspections and tests could rely on a person's experience where failures have occurred. But initially setting ITPM must depend upon RAGAGEP.

Keeping an AIM program current with changing RAGAGEP is also very important. The updated RMP standard (2024) now requires a RAGAGEP Gap Analysis that considers the latest RAGAGEP when conducting Process Hazard Analyses (PHAs). The purpose is to focus on "Any gaps in safety between the codes, standards, or practices to which the process was designed and constructed and the most current version of applicable codes, standards, or practices."

Defining the scope and applicability of RAGAGEP at the beginning of implementing or improving an AIM program and updating the program as needed when RAGAGEP changes will ensure that each facility creates appropriate and relevant AIM programs that comply with the company's expectations.

4 Gaining Stakeholder Buy-in for the AIM Program

When launching or improving an AIM program, senior management must visibly support it with clear policies, their presence, and continued resources to implement and sustain it efficiently and effectively. The key stakeholders, in this case, the reliability and maintenance teams, must also be included to ensure the new policies and procedures are reasonable and will ensure the equipment is fit for its intended use.

As the Company's standards and procedures were being created or revised, a team of facility SMEs was part of the process. They either created the documents or reviewed the drafts to critique the content. This process created immediate buy-in from the team SMEs and helped to foster confidence in the process and documents from their peers at the other facilities.

When training was conducted on the new policies or procedures, a senior manager would start the call and explain why that topic was important to the Company and how it would benefit the facilities in terms of productivity and safety. Other activities to build stakeholder buy-in included frequent meetings with the program and facility managers to address concerns. A presentation was also created by the program manager and delivered to facility managers to summarize past incidents due to equipment failure and explain how the AIM program could help prevent future ones. Not everyone accepted the new AIM program immediately, but as these efforts continued, the majority of impacted people did.

As the AIM program was implemented, another way that buy-in was fostered was by being flexible. The gasket management program that was implemented was unrealistic in the frequency and depth of required inspections. The facilities were asked to attempt to implement the program as written, but it became clear that the requirements were excessive. After consulting with and visiting many facilities, the program manager worked with the SMEs to modify the gasket program to an achievable level. The facility personnel were appreciative that they had been listened to and that the requirements were modified to a level where they could comply.

Creating or modifying asset integrity policies and procedures may require an iteration or two to create a document that fulfills the intent while also being reasonable and executable.

5 Recognizing the Need for Other Programs

While creating or improving an AIM program, other requirements may become evident. During the launch of this program, the program manager quickly recognized that most facilities were not maintaining the power equipment. These same facilities had backup generators that were required as safeguards from risk assessments. They were installed to maintain power to critical equipment, such as reactors, after a power failure until the process could be brought to a safe state. As the single-line diagrams for the power from the generator to the critical equipment were followed, it became clear that other power equipment was in-between them that had to work during a power failure. This equipment included Motor Control Centers (MCCs) and other electrical panels.

As the requirements from NFPA 70B, *Standard for Electrical Equipment Maintenance*, were documented in a procedure, the requirement for having an electrical safety program from NFPA 70E, *Handbook for Electrical Safety in the Workplace*[11], became clear. This standard ensures that employees are protected with the proper Personal Protective Equipment (PPE) when accessing and maintaining the power equipment. But to understand what PPE is required, arc flash and coordination studies are needed to document the arc flash boundaries and the required PPE to protect workers. Developing this additional program while launching the AIM program was not trivial, but it had to be done. As the facilities began to conduct these studies, several found power equipment that was too dangerous to access at all. No PPE was sufficient to protect the workers from the potentially severe arc flash. In these cases, the equipment was primarily modified to reduce the potential arc flash or occasionally replaced when modification was not possible. If the Company had not implemented this program, it is possible that a maintenance person could have been severely injured or killed in the course of maintaining this dangerous equipment.

Other related programs that companies may be missing are a machine safeguarding program and the maintenance of those safeguards once they are installed. Companies may also need a radiation program per OSHA 29 CFR 1910.1096, Ionizing Radiation[12], if they use equipment to assist with Positive Material Identification or conduct certain non-destructive tests, such as radiographic testing, that contain radiation. Many facilities also are required to have a Positive Material Identification program to ensure the right material of construction is used in services where catastrophic failure could occur with the wrong material.

As an AIM program is created or improved, embrace the related required standards that are discovered and implement them to ensure personnel are safe and equipment is functioning as intended.

6 Creating AIM Program Training and Defining Run to Failure

Training a large organization on a new or improved AIM program can be daunting. The policies and procedures must be rolled out by knowledgeable personnel in an efficient manner. When the Company was rolling out the AIM program, the organization had over 100 global facilities. Training in person was not reasonable or feasible. Virtual training was scheduled at two different times that fit with the work schedules of most facilities. Translators were available for countries that requested them. As discussed, senior managers started the call, Subject Matter Experts provided the training and answered technical questions, and the program manager was on each call to answer the program questions. The SME's and program manager were also available to answer questions as the facilities implemented the requirements. The training emphasized the policies, standards, and procedures that would be used to comply with the PSM mechanical integrity requirements, ensure the equipment worked as intended, and prevent incidents.

The program was rolled out one topic or equipment category at a time. The facilities were given a set number of months to complete the required tasks. The first task was to list all included equipment in the covered process and create a critical equipment list, preferably from the IPLs within the Layer of Protection Analyses (LOPAs) or from the safeguards within the PHAs for the higher-risk scenarios at each facility. Higher risk was defined based on the risk matrix the Company used, so this was very clear. Facilities could request direct assistance from the program manager to help facilitate any of the tasks, which were done virtually or in person, depending on the topic and what was needed.

As the PSM equipment lists were being created, the conversation began about how the organization would deal with equipment that was run to failure. OSHA does allow equipment to run to failure or "breakdown" in the covered process if the failure does not cause or contribute to a catastrophic event. The definition that allowed breakdown equipment stated that it had to adhere to the following rules:

- It cannot contain highly hazardous chemicals.
- It cannot have any pathway to a source of hazard.
- It cannot have any controls or relief systems that potentially could create hazardous conditions.
- It cannot be an integrated safety support system.
- It cannot be a source of needed power for critical equipment.
- It should not significantly impact production or downtime.

If the equipment met the definitions above, including that its failure would not have a significant impact on production and downtime, then it could be run to failure.

7 Tracking a Performance Indicator for Implementation Progress

Tracking this large AIM program rollout of many tasks over multiple years could have been a huge effort. Many ways to track the progress of the facilities were discussed, and various metrics and performance indicators were proposed; however, the biggest concern was that the plants were already working incredibly hard to implement this program. Asking them to stop the implementation to report on metrics that involved gathering information and determining exactly where they were on every task seemed like a waste of valuable time.

So, as the due date for each set of tasks arrived, an email was sent by the program manager to a designated person at each facility. For each task that just came due and any past tasks, the email stated, Please indicate the level of completion for this task using one of the following statements:

- Have not started
- Just started
- About halfway done
- Almost done
- Done

The answers were assigned a number with zero for not started, 25% for started, 50% for about halfway, 75% for almost done, and 100% for done. This simple performance indicator was easy for them to complete and easy to put into an Excel table for the program manager to track. Summaries could be created using pivot tables to report to management and the table helped the program manager to see which plants were struggling. Few additional resources were available, but when the right people were free, they could be assigned to assist the struggling plants. The program manager also assisted where she could.

After about five years of implementation, ten plants were clearly behind the others. Formal corporate audits were conducted at each facility with mechanical integrity being audited by the program manager. The audit findings created a clear roadmap for the facilities to define the requirements that were not being met. About a year after the audits, the ten facilities were compliant with all requirements except where long-term projects were required to address the issues.

8 Conclusion

The successful implementation of an Asset Integrity Management (AIM) program requires a structured approach that includes defining equipment categories, ensuring compliance with RAGAGEP, gaining stakeholder buy-in, and continuously adapting to new challenges. This Company's experience in launching a global AIM program highlighted the importance of flexibility, collaboration with facility subject matter experts (SMEs), and iterative improvements to policies and procedures.

Training and implementation tracking using one performance indicator played a crucial role in ensuring organization-wide adoption, with simplified reporting mechanisms allowing efficient progress monitoring across all facilities. Facilities that struggled received targeted support, and corporate audits helped drive full compliance.

Ultimately, implementing an AIM program is not a one-time initiative but a continuous process of identifying risks, improving maintenance practices, and ensuring compliance with changing RAGAGEP. Organizations must remain proactive, adaptable, and committed to protecting personnel, assets, and the environment while maintaining operational efficiency.

9 References

1. OSHA 29 CFR 1910.119, Process Safety Management (PSM).
2. International Electrotechnical Commission, IEC 61511, *Functional safety – Safety Instrumented Systems for the Process Industry Sector standard.*
3. NFPA 70B, *Standard for Electrical Equipment Maintenance.*
4. NFPA 30, *Flammable and Combustible Liquids.*

5. NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*
6. NFPA 10, *Portable Fire Extinguishers.*
7. NFPA 12, *Carbon-Dioxide Fire-Extinguishing Systems.*
8. EPA chemical Accident Prevent Provisions, aka Risk Management Plan (RMP) 40 CFR Part 68.
9. OSHA CPL 03-00-004, *Petroleum Refinery PSM Refinery National Emphasis Program*.
10. American Petroleum Institute (API) 592 (under consideration), *Elements for the Establishment of a Fixed Equipment Mechanical Integrity Program*.
11. NFPA 70E, *Handbook for Electrical Safety in the Workplace.*
12. OSHA 29 CFR 1910.1096, Ionizing Radiation.